FISH COMMUNITIES AND MACROHABITAT VARIABLES IN O'FALLON CREEK, MONTANA

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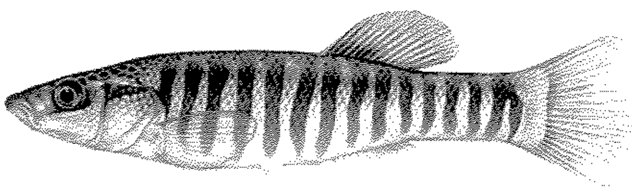
May 2003



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INTRODUCTION

Little research has inquired into the distribution, habitat requirements, and ecological relationships of fishes in small prairie streams in eastern Montana. Clancey (1978) conducted a study of longitudinal distribution of fishes and aquatic habitats in Sarpy Creek, Big Horn and Treasure counties, to provide baseline information for the assessment of potential impacts of coal mining in the area. Barfoot (1993, 1999) studied longitudinal distribution of fishes and aquatic habitats in Little Beaver Creek, Carter and Fallon counties, Montana, and Bowman and Slope counties, North Dakota, in order to test the hypothesis that longitudinal zonation of fish communities in streams is related primarily changes in stream geomorphology.

Several wider surveys have sought to develop baseline data on fish communities and habitats in eastern Montana in order to assess the potential impacts of future energy development, particularly strip mining of coal and on-site power generation, on these communities. The results of these studies were collected and summarized by Elser et al. (1980).

Of these more extensive surveys, two generated data on fish communities in smaller prairie streams. Elser et al. (1978) conducted an inventory of fishes and aquatic habitats in Beaver Creek, three of its tributaries, and seven north-flowing tributaries of the lower Yellowstone River. Morris et al. (1981) conducted a similar inventory of 45 tributaries of the lower Yellowstone River and assigned value ratings to each stream based on habitat and species value and recreational fishery potential.

Given the potential impacts of current land uses, including livestock grazing and irrigated agriculture, and of future energy development, including coal bed methane production, on stream fish communities in eastern Montana, it would be desirable to learn more about the distribution and habitat requirements of stream fishes in the region. Moreover, from the perspective of basic ecological research, it would be interesting to further explore factors that influence longitudinal zonation of fish communities in small prairie streams.

From 1997 to 2000, Barnes (1997, 1999), Barnes and Westlind (2000), and Barnes and Silbernagle (2001) conducted a quantitative study of fish population densities, longitudinal distribution, and macrohabitat variables in Burns Creek, a perennial groundwater driven stream in Dawson and Richland counties, Montana. Results of this study suggested that a few relatively "fixed" macrohabitat factors as well as random contingent phenomena both strongly influenced density and longitudinal distribution of fishes in that system. The most important "fixed" factors were stream width-depth ratio, riparian vegetation height and overhang, and instream cover, whereas the most important contingent phenomena were stormflow flushing and changing patterns in number and location of beaver (*Castor canadensis*) dams.

Because it is perennial and groundwater driven, Burns Creek may not typify small prairie streams in eastern Montana, most of which are runoff driven and highly seasonal. Therefore, during the summers of 2001 and 2002, we applied the sampling methodology developed for Burns Creek to O'Fallon Creek, a largely runoff driven tributary of the lower Yellowstone River in Prairie, Custer, Fallon, and Carter counties, Montana (Barnes et al. 2002). This report summarizes the results of that study during 2002.

STUDY AREA

O'Fallon Creek originates in Carter County and flows northwesterly 252.1 km through Fallon, Custer, and Prairie counties to its confluence with the Yellowstone River at river kilometer 208.4 near the village of Fallon (Figure 1). Channel elevation ranges from 1066.8 m at the main stem headwaters to 652.3 m at the mouth, with a mean gradient of 1.64 m/km. O'Fallon Creek is a fifth order stream with two major tributaries: (1) Sandstone Creek, which originates southeast of Baker and flows northwesterly 104.6 km to its confluence with O'Fallon Creek just upstream of the village of Ismay and (2) Pennel Creek, which originates northwest of Baker and flows northwesterly 106.0 km to its confluence with O'Fallon Creek just downstream of Ismay. Other tributaries greater than 10 km in length include Ash Creek, Buffalo Creek, Hay Creek, Lame Jones Creek, Lily Creek, Mile Creek, Miles City Creek, Milk Creek, O'Fallon Creek East Fork, Pine Creek, and Whitney Creek. The whole system drains 4,079.6 km^2 (Morris et al. 1981, NRIS 2003).

The O'Fallon Creek watershed occupies the edge of the glaciated Missouri Plateau, Short Grass Region, Great Plains Province. The climate is semiarid continental, with mean annual temperature of 14.4°C (daily extremes from -42.8°C on 20 January 1954 to 43.9°C on 19 August 1995 and 15 July 2002), mean annual precipitation of 29.2 cm (mean annual range from 13.6 cm to 46.6 cm), and mean annual snowfall of 39.6 cm (mean annual range from 0.0 cm to 110.5 cm) with little accumulation (as measured at Terry, Montana, 1949-2002, WRCC 2003). Upland terrain consists of rolling hills that have been dissected into badlands by O'Fallon Creek and its tributaries. Downstream of I-94, O'Fallon Creek cuts through alluvial terraces and emerges onto the floodplain of the Yellowstone River. Land use on the watershed is 76.9% rangeland, 22.3% agricultural, 0.5% evergreen forest, 0.1% urban, 0.1% water, and 0.1% bare ground (NRIS 2003).

Non-crop upland vegetation of the watershed consists predominantly of grasses (Poaceae) and sagebrush (*Artemesia* spp.) with scattered stands of ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*). Valley floors also support scattered stands of eastern cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), Russian olive (*Eleagnus angustifolia*), and buffaloberry (*Shepherdia canadensis*). Riparian and littoral vegetation is dominated by sedges (*Carex* spp.), rushes (*Juncus* spp.), cattails (*Typha* spp.), snowberry (*Symphoricarpos albus*), milkweed (*Asclepias* spp.), and willow (*Salix* spp.).

The O'Fallon Creek watershed is underlain by Cretaceous and Paleocene sedimentary rocks consisting primarily of highly erodible sandstones and shales. Exposed rocks in the watershed consist of non-marine sediments of the Fort Union Formation, which contains economically extractable deposits of coal and discharges significant amount of groundwater (Alt and Hynd 1986, Morris et al. 1981).

The flow regime of O'Fallon Creek, as measured from 1977 to 1992 at a U.S. Geological Survey (USGS) gauging station near Ismay, is typical of small prairie streams in eastern Montana (Figures 2 and 3). Mean monthly discharge is 1.75 m^3/s in March, declining thereafter to late summer, fall, and winter lows of 0.02 to 0.56 m^3/s (Figure 3). Mean annual discharge for the period of record was 0.43 m^3/s. However, annual, monthly, and daily discharges are highly variable in response to long-term variations in annual precipitation and to short-term local precipitation events, especially late spring and summer rainstorms. Mean annual discharge has ranged from 0.03 m^3/s in 1980 to 1.77 m^3/s in 1978. The highest recorded instantaneous flow for O'Fallon Creek was 133.0 m^3/s on 3 July 1976, while zero flow was frequently recorded during late summer to late winter, especially after 1987 (USGS 2003). It is likely that isolated pools persist during periods of recorded zero flow.

MATERIALS AND METHODS

Fish population densities and macrohabitat variables were determined at 20 sites in the O'Fallon Creek system from 24 July to 15 August 2002 (Figure 1, Table 1). A site was generally defined as one contiguous unit of riffle, run, and pool habitats; these habitat types were defined according to Armantrout (1998). Low flow in the stream system during the sampling period made riffle and run habitats hard to distinguish, so we merged these two habitat types (hereafter referred to as riffles) during sampling (Figure 4). Only 40-m lengths of extremely long pools and riffles were included in fish and macrohabitat sampling. Sites 18, 19, and 20 lacked riffle-pool development, so these sites were defined as 40-m lengths of pool (Figures 5, 6, 7).

On arrival at each site, a metric Hip Chain distance measurer (No. 06220, Legend, Inc., Reno, NV) was used to measure total site length and the lengths of component riffles and pools. Orange DayGlo ribbon (DayGlo Color Corp., Cleveland, OH) was tied to conspicuous littoral vegetation every five meters to serve as a baseline for installing block seines, determining flow velocity, and spacing macrohabitat sampling transects. A water sample for total suspended solids (TSS) was then collected, dissolved oxygen, conductivity, and pH were measured, and initial water and air temperatures were recorded as described below. Next, block seines were installed for fish sampling. After fish sampling was completed, macrohabitat variables were measured or estimated as described below.

Minnow traps (length = 38.1 cm; outer diameter = 17.8 cm; entry port diameter = 5.0 cm) were used to semi-quantitatively sample fish communities at Site 18. This headwaters site contained dense submerged aquatic vegetation and mucky sediment that made seining ineffective. Eighteen traps were baited with commercial dry dog food and set equidistantly in the 40-m site overnight on 31 July-1 August 2001. Fish were subsequently removed from the traps, identified with the aid of Holt and Johnson (1996) and Gould (1998), counted, and returned to the stream.

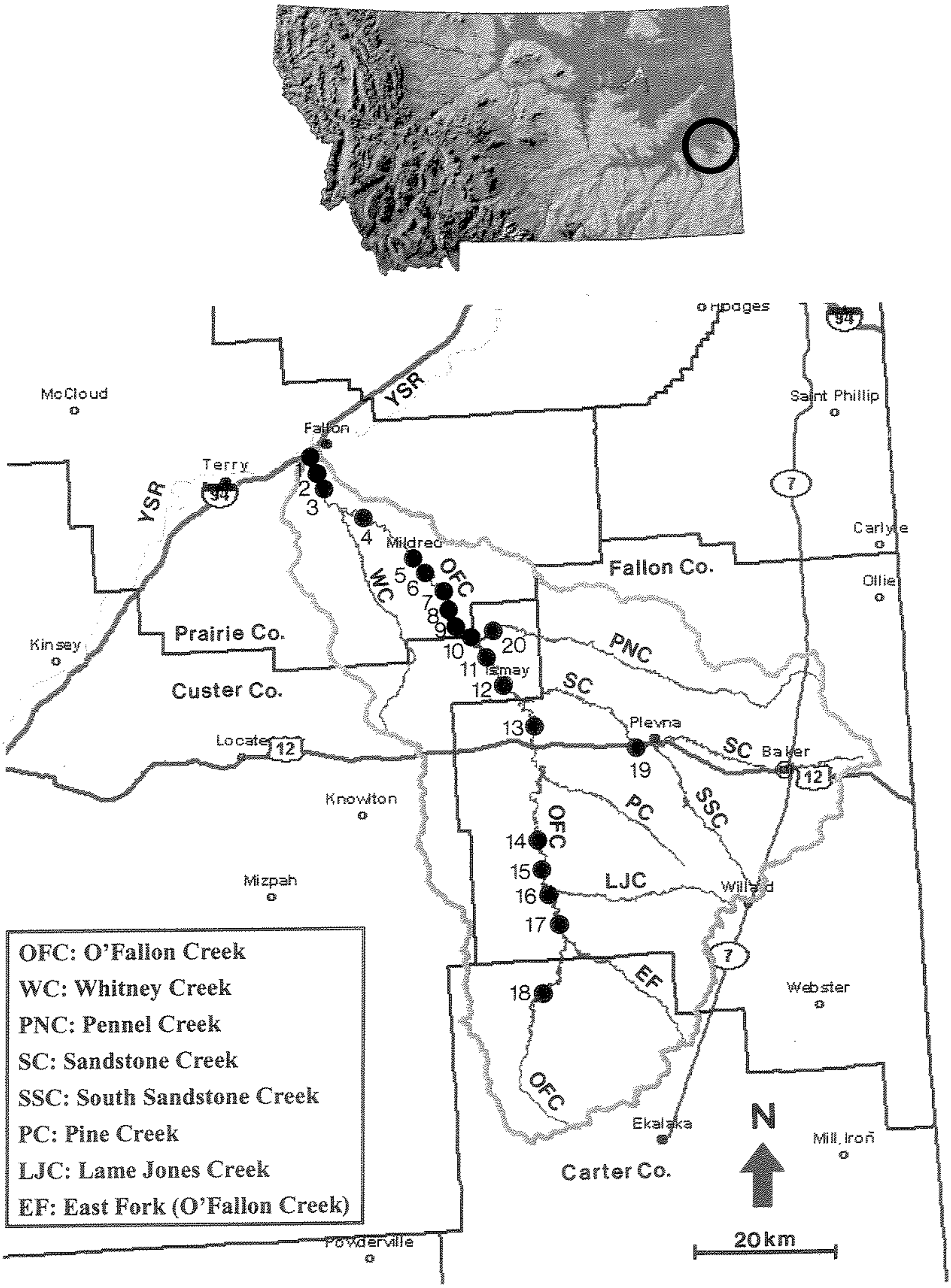

Figure 1. Map of the O'Fallon Creek system, Montana, showing sites (●) sampled in 2002 (NRIS 2003).

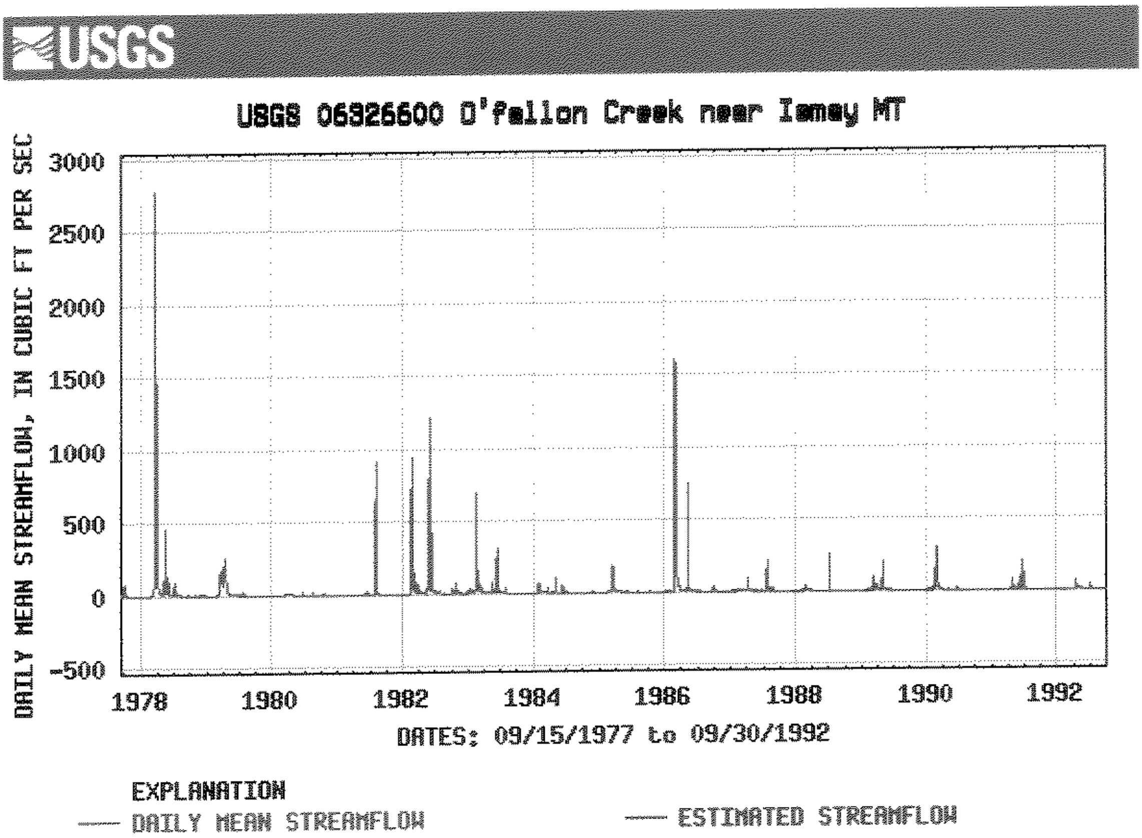

Figure 2. Daily mean streamflow (ft³/sec), O'Fallon Creek near Ismay, Montana, 1977-1992, Gauging Station 06326600 (USGS 2003).

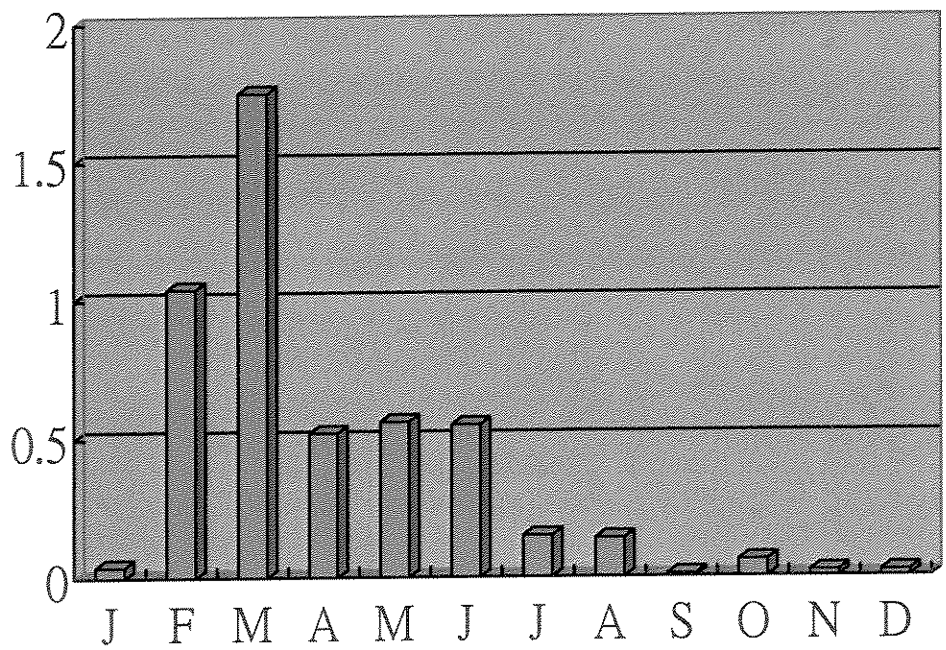

Figure 3. Monthly mean streamflow (m³/sec), O'Fallon Creek near Ismay, Montana, 1977-1992, Gauging Station 06326600 (USGS 2003).

Table 1. Locations of sampling sites in the O'Fallon Creek system, Montana, 2001-2002.

Site No. 2002 (2001)	County	Township	Range	Section	Latitude	Longitude	Date
	O'Fallon Creek						
1 (1)	Prairie	12N	52E	2	46°49'77"	104°50'30"	8/10/2002
2 (2)	Prairie	12N	52E	2	46°49'67"	105°08'90"	7/27/2002
3	Prairie	13N	52E	3	46°49'58"	105°09'31"	8/03/2002
4 (3)	Prairie	11N	53E	5	46°46'77"	104°50'30"	8/13/2002
5	Prairie	11N	54E	13/24	46°42'05"	104°59'53"	7/26/2002
6 (4)	Prairie	10N	54E	4	46°40'92"	104°58'23"	7/24/2002
7 (5)	Prairie	10N	54E	9	46°38'63"	104°56'15"	7/31/2002
8	Prairie	10N	54E	3/10	46°38'44"	104°55'12"	8/02/2002
9 (6)	Prairie	10N	54E	15	46°37'38"	104°54'12"	7/30/2002
10	Prairie	10N	54E	14	46°31'94"	104°54'00"	8/01/2002
11	Custer	9N	55E	8	46°32'77"	104°50'30"	8/08/2002
12	Custer	9N	55E	17	46°31'85"	104°49'33"	8/08/2002
13 (7)	Fallon	8N	55E	20	46°26'44"	104°45'36"	8/06/2002
14 (8)	Fallon	7N	56E	19	46°21'02"	104°45'82"	8/14/2002
15	Fallon	6N	56E	6	46°18'77"	104°50'30"	8/09/2002
16	Fallon	6N	56E	6	46°17'73"	104°45'38"	8/16/2002
17 (9)	Fallon	5N	56E	28	46°16'44"	104°46'31"	8/07/2002
18 (10)	Carter	4N	56E	32	46°03'48"	104°47'48"	8/15/2002
	Sandstone Creek						
19	Fallon	8N	57E	36	46°24'57"	104°32'67"	8/17/2002
	Pennel Creek						
20	Custer	9N	55E	5	46°28'51"	104°49'30"	8/17/2002

At Sites 1-19 we used a simple DeLury (1947) type capture-removal approach to estimate fish community densities in adjacent riffle and pool habitats. Block seine installation and fish sampling were done before macrohabitat evaluation in order to minimize movement of fish out of the disturbed site. Two 7.5-m x 1.2-m x 6.3-mm mesh straight seines, one 8.2-m x 1.5-m x 6.3-mm mesh bag seine, and one 12.1-m x 1.8-m x 6.3-m straight seine were used as block seines. Block seines were installed at the upstream and downstream ends of each site and between adjacent riffles and pools (i.e., three block seines per site) (Figure 8).

In pools, we usually used a short, straight minnow seine (3.6-m x 1.5-m x 6.3-mm mesh) to make successive removal passes through each isolated section. In wider pools, a bag seine (8.2-m x 1.5-m x 6.3-mm mesh) was used to make removal passes. In all pools, two operators towed the working seine from the downstream end to the upstream end of each isolated section. The lead line was kept on the stream bottom, and the seine was landed at a convenient upstream location.

Figure 4. Riffles (dry) and pools, O'Fallon Creek, Fallon County, MT, Site 10, 1 August 2002.

Figure 5. Headwaters, O'Fallon Creek, Carter County, MT, Site 18, 15 August 2002.

Figure 6. Sandstone Creek, Fallon County, MT, Site 19, 17 August 2002.

Figure 7. Pennel Creek, Custer County, MT, Site 20, 17 August 2002.

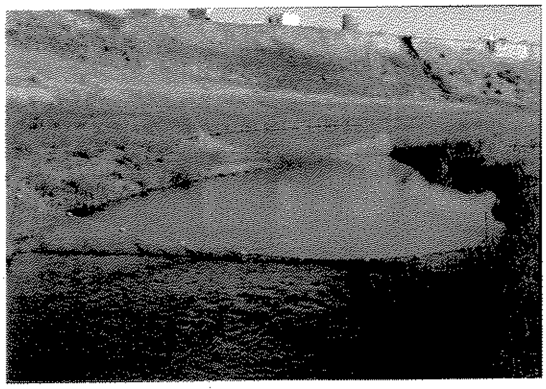

Figure 8. Block seines, O'Fallon Creek, Prairie County, MT, Site 3, 3 August 2002.

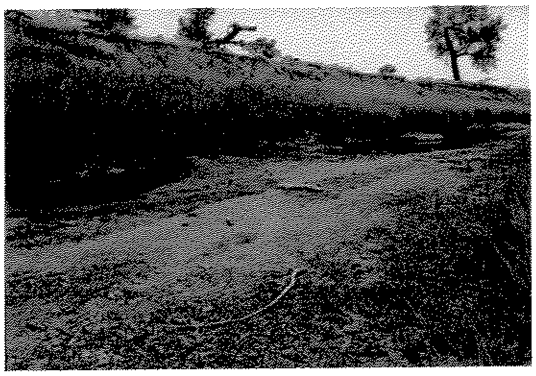

Figure 9. Dry beaver pond, O'Fallon Creek, Custer County, MT, Site 11, 6 August 2002.

Figure 10. Riparian vegetation, O'Fallon Creek, Fallon County, MT, Site 13, 6 August 2002.

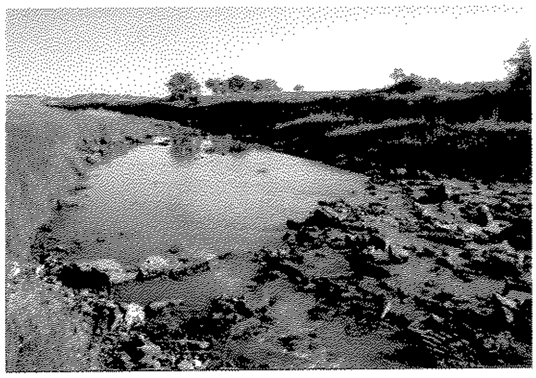

Figure 11. Boulder riffle, lower O'Fallon Creek, Prairie County, MT, Site 1, 10 August 2002.

In riffles, towing the seine was ineffective due to high flow velocities at downstream sites, extremely shallow depths at upstream sites, and the tendency of dominant riffle species to hide under cobbles. Therefore, one operator held the working seine stationary at the downstream end of the isolated section, across the whole wetted channel and with the lead line on the stream bottom. The second operator then "kicked down" the riffle or run from upstream to downstream, agitating the substrate with his feet. Finally, the seine was lifted quickly by both operators in midstream. We were unable to make fish population estimates on several riffles due to extremely low flow; riffles were either dry or reduced to shallow trickles that we were unable to seine. In such cases, if small fish were present, they were sampled qualitatively with a dip net.

The number of removal passes (by towing or kicking) ranged from three to five and depended on how quickly we achieved a noticeable reduction in catch. After each removal pass, fish were removed from the seine, held in a bucket of aerated water, identified using Holt and Johnson (1996) and Gould (1998), counted, and returned to the stream downstream of the lowest block seine. To estimate the density of fish in isolated riffles, runs, and pools, we regressed catch per pass on sum of catches to yield a gross population estimate. This estimate was then divided by the measured surface area of the habitat unit (length x mean width) to yield number of individuals per 100 m^2.

The following macrohabitat variables were measured or visually estimated at each site after fish sampling was completed unless otherwise noted.

Location:
- latitude and longitude
- landmark photography and notation on USGS 7.5-min quadrangle map

Water Quality:
- water temperature and air temperature (initial and final)
- dissolved oxygen
- pH
- conductivity
- total suspended solids

Streamflow:
- flow velocity
- discharge

Channel Morphology:
- total site length and lengths of component riffle, run, and pool habitats
- stream width (wetted width and channel width)
- stream depth

Streambed Composition:
- relative substrate composition
- sediment depth
- embeddedness

Riparian Conditions:
- adjacent land use (left and right banks)
- buffer width (left and right banks)
- bank erosion (left and right banks)
- bank height at water's edge (left and right banks)
- entrenchment bank height (left and right banks)
- channel canopy shading

Cover:

- vegetative height at water's edge (left and right banks)
- vegetative overhang (left and right banks)
- bank undercut (left and right banks)
- woody and other debris
- emergent and submerged aquatic vegetation

Macrohabitat variables were measured or visually estimated using a transect approach based on Simonson et al. (1994). Using a Hip Chain distance measurer as described above, transects were spaced at five-meter intervals perpendicular to the direction of streamflow, beginning one meter above the lower end of each site and ending at the last five-meter interval below the upper end of each site. For riparian variables, transects were extended 10 meters inland from water's edge. Transects were numbered and worked from downstream to upstream, with the left bank and the right bank designated facing downstream. Variables were measured or visually estimated along a 0.3-m wide band centered on the transect line. A 20-m length of 0.25-in (31.8-mm) white nylon line and two metal stakes were used to mark transects while they were worked.

Location. Each site was marked on a standard USGS 7.5-min quadrangle map, and landmarks were noted. Latitude and longitude of each site were determined with a GPS Pioneer Satellite Navigator (Magellan Systems Corporation, San Dimas, CA). For reference and future identification of sites, four color photographs were taken at each site: (1) upper end facing upstream; (2) upper end facing downstream; (3) lower end facing upstream; (4) lower end facing downstream.

Water Quality. Water and air temperatures were measured with a pocket field thermometer at the lower end of the pool at each site at the beginning and at the end of sampling. Dissolved oxygen concentration, water temperature, and conductivity were determined with a YSI Model 85 oxygen, conductivity, salinity, and temperature meter (Yellow Springs Instruments, Inc., Yellow Springs, OH) and pH with a pHep 3 pH meter (Hanna Instruments, Woonsocket, RI) at the lower end of the pool of each site before fish sampling. Whole water samples were collected in one-pint (0.48-liter) glass jars before fish sampling at the upper ends of sites 1, 2, 4, 6, 7, 9, 12, 13, 14, 16, 18, and 19. These samples were analyzed for total suspended solids (TSS) by Amatec Services, Inc. (Billings, MT) using SM 2540D (Clesceri et al. 1999).

Streamflow. Flow velocity was measured at each site by timing three times the transit of a plastic fishing float over a measured distance of riffle or run (usually 10 m). An ExTech Digital Stopwatch/Clock (ExTech Instruments Corporation, Waltham, MA) was used for timing, and the results of three runs were averaged to yield mean flow velocity. Discharge was calculated by multiplying the cross-sectional area of the water column (using depth and width measurements as described below) by mean flow velocity (McMahon et al. 1996). Flow velocity through pools was usually too slow to measure using the buoyant object method, especially with wind interference.

Channel Morphology. Total length of each site and lengths of component riffle, run, and pool habitats were measured using a Hip Chain distance measurer as described above. Wetted width and channel width were measured to the nearest inch (2.54 cm) using a six-foot (1.83-m) SECO wooden grade stick graduated in inches (No. 43428, Forestry Suppliers, Inc., Jackson, MS) or a 300-ft (91.4-m) fiberglass measuring tape graduated in inches (Model KL-300-18, Keson

Industries, Inc., Naperville, IL) along transects at each site. When different from wetted width, channel width was delimited by the presence of matted or silt-covered vegetation that had obviously been recently submerged or by the presence of white evaporite deposits. Water depths were measured by grade stick at five equidistant points along transects at each site, beginning at channel center and proceeding shoreward to within 10 cm of the left and right banks. This created six equal-width cells for calculation of mean depth and channel cross-sectional area.

Streambed Composition. Substrate material definitions of Simonson et al. (1994) were used. Substrate composition and embeddedness were estimated visually to the nearest five percent along transects at each site. Sediment depth was defined as the depth of yielding material (silt or muck) overlaying a non-yielding substrate (bedrock, boulders, rubble, cobbles, gravel, or sand). In the field, stream bottom material which could be penetrated with the grade stick was considered sediment, and its depth was measured by grade stick along transects at each site at the same points used for measuring water depth. Embeddedness was defined as percent of rubble, cobble, or gravel particles covered by sediment.

Riparian Conditions. The land use classification and riparian definitions of Simonson et al. (1994) were used. Riparian land use and canopy shading were estimated visually to the nearest five percent along transects at each site. Buffer width, bank erosion, bank slumping, bank height at water's edge, and entrenchment bank height were measured by grade stick, measuring tape, or 25-ft (7.62-m) extension pole (Model 90180, Crane Enterprises, Inc., Mound City, IL) to the nearest foot (0.30 m) at each site, except for bank height at water's edge, which was measured to the nearest inch (2.54 cm). Bank angle (with respect to horizontal) of both water's edge and entrenchment banks was measured with a modified industrial protractor (No. 3791N, Hempe Manufacturing Co., New Berlin, WI). Buffer width was defined as the width of undisturbed riparian vegetation extending from water's edge to a point 10 m inland. Bank erosion was defined as the width of bare riparian soil from water's edge to a point 10 m inland, and slumping was defined as the width of detached whole riparian soil masses, vegetated or not, from water's edge to a point 10 m inland. An entrenchment bank was defined as a bank higher than the water's edge bank and separated from water's edge by a distance of 10-30 m. Entrenchment banks obviously contained streamflow during peak flow periods and often coincided with water's edge banks on outside meander bends.

Cover. Cover was defined as any instream material, riparian material, or streambank configuration that could provide protection for most fishes of the size range (< 15 cm) found in O'Fallon Creek. The amount of wetted channel bottom covered by woody debris, other debris, emergent vegetation (aquatic or flooded riparian), or submerged vegetation (aquatic or submerged riparian) was visually estimated to the nearest five percent along transects at each site. In order to qualify as cover, debris or vegetation had to occur in water at least 15 cm deep; Simonson et al. (1994) used a one-foot (3-cm) water depth criterion, but their approach emphasized cover requirements of larger game fishes. Riparian vegetative overhang, vegetative height at water's edge, and bank undercut were measured by grade stick to the nearest inch (2.54 cm) along transects at each site. In order to qualify as cover, vegetative overhang, vegetative height, and bank undercut had to be at least 15 cm.

Other. General observations on flora, fauna, hydrology, geology, and water quality and land use were noted at each site.

RESULTS AND DISCUSSION

Stream Flow. Upstream of the Fallon-Carter county line, the headwaters of O'Fallon Creek (Site 20) consisted of a series of long, densely vegetated pools (Figure 5). This section of the creek exhibited no active flow during the sampling period and is probably not very responsive to storm events and surface runoff because the associated drainage area is relatively small. Water in the channel may represent surface detention over a shallow impermeable layer or an intersection of the channel and the regional water table. From Site 17 downstream to Site 1 at the mouth, discharge ranged from 0.0 m^3/s to 0.9 m^3/s, within the observed range of mean monthly discharge for August from 1977 to 1992 (0.0 m^3/sec to 1.6 m^3/sec) (Table 2) (USGS 2003). Discharge was highest near the mouth (Sites 1 and 2) due to return flow from irrigated cropland adjacent to the Yellowstone River. Where zero discharge was recorded, riffles were either dry or reduced to trickles. Pools at all sites retained water, although the volume was extremely reduced in a washed out beaver pond at Site 11 (Figure 9).

Water Quality. Water quality variables were relatively uniform longitudinally during the sampling period. Water temperature averaged 19.0°C, ranging from 13.3°C (Site 19) to 26.6°C, and generally responded daily to air temperature, which averaged 23.9°C and ranged from 15.6°C to 40.0°C (Table 2). Site 19 in Sandstone Creek (13.3°C) received a cold spring inflow. Excluding Site 18, dissolved oxygen (DO) averaged 5.9 mg/l, ranging from 4.2 mg/l to 7.2 mg/l, and was adequate to support aerobic aquatic life (Table 2). DO concentrations in the 4.0-5.0 mg/l range usually occurred in shallow pools isolated between dry riffles and experiencing no through flow. Lower DO (3.1 mg/l) at Site 18 was probably due to diurnal oxygen depletion by photosynthesis of submerged aquatic vegetation in this shallow lentic environment. Average pH was 8.6 with little variation longitudinally (Table 2).

Concentrations of total suspended solids (TSS) varied longitudinally, averaging 72.2 mg/l and ranging from 14.7 mg/l to 150.8 mg/l; higher concentrations probably reflected local disturbances such as bank erosion, beaver activity, or cattle use rather than downstream accumulation of TSS (Table 2). O'Fallon Creek probably receives a relatively high natural inorganic sediment load due to erosion of the sparsely vegetated badlands that comprise a large part of its watershed.

Conductivity was relatively high, averaging 1909.2 µS and ranging from 325 µS to 3950 µS (Table 2). High conductivity reflects high concentrations of total dissolved solids (TDS), which are derived from runoff inputs of a large, sparsely vegetated watershed in a highly evaporative climate. Conductivity over 2000 µS usually occurred in shallow isolated pools where evaporation had concentrated TDS. At Sites 1 and 2, lower conductivity may have resulted from dilution of TDS by irrigation return flow.

Table 2. Water quality, flow, and channel morphology variables for 20 sites in the O'Fallon Creek system, Montana, 24 July to 15 August 2002.

Site*	Variable**								
	T (°C)	DO (mg/l)	C (µS)	TSS (mg/l)	pH	Q (m^3/sec)	L (m)	W (m)	D (cm)
1 R						0.9	10	13.7/16.2	14.9
1 P	14.4	7.2	325	78.4	8.6		62	9.5/13.9	44.8
2 R						0.8	40	4.8/4.8	17.6
2 P	22.0	5.9	585	128.1	8.4		331	15.8/15.8	42.1
3 P	18.3	6.5	535		8.3		23	6.6/7.4	31.4
3 R						0.4	12	6.4/6.4	13.3
4 R						0.1	15	2.6/8.1	11.4
4 P	12.5	6.6	980	137.0	8.4		149	8.2/10.5	18.6
5 R						0	55	2.8/8.4	3.3
5 P	20.9	5.7	1490		8.5		25	8.2/15.2	18.4
6 P	25.7	6.8	960	14.7	8.4		96	10.7/13.2	21.4
6 R						0	50	5.4/10.2	3.7
7 R						0	85	7.4/7.4	0
7 P	20.4	4.5	950	150.8	8.3		315	12.7/20.6	16.7
8 R						0	20	1.0/6.7	0.5
8 P	17.0	6.5	1200		8.5		138	10.1/12.2	25.4
9 P	22.3	5.2	1728	78.7	8.5		70	9.1/9.3	50.7
9 R						0	30	0/10.4	0.8
10 R						0	20	0/12.3	0
10 P	15.0	6.1	1700		8.5		50	7.4/8.6	17.8
11 P	21.9	4.2	3200		8.9		77	2.6/7.7	16.2
11 R						0	40	0/8.0	0
12 P	21.8	4.6	3950	27.4	8.7		16	5.2/6.4	36.6
12 R						-	12	0.8/5.0	1.0
13 R						0	20	2.4/3.8	4.0
13 P	21.6	6.7	1580	42.0	8.5		50	3.8/5.0	22.0
14 R						-	20	1.7/2.8	3.6
14 P	16.1	5.6	1900	75.5	8.9		400+	5.4/6.3	32.7
15 R						0	30	1.9/4.1	3.0
15 P	19.6	5.8	2800		8.7		404	3.6/6.2	12.3
16 P	18.0	6.0	2900	15.5	8.7		187	6.5/7.4	41.0
16 R						<0.1	35	1.7/3.3	5.1
17 R	18.3	5.7	2800		8.7	<0.1	12	2.3/7.0	1.2
17 P							64	7.0/7.0	51.3
18 P	23.2	3.1	3800	59.9	8.7		400+	0/3.4	0
19 P	13.3	7.5	2300	59.1	8.7		400+	3.5/3.5	106.3
20 P	18.1	6.1	2400		8.6	-	400+	3.7/3.7	107.8

*Listed in order of downstream to upstream occurrence (R = riffle; P = pool).

** T = mean water temperature; DO = dissolved oxygen; C = conductivity; TSS = total suspended solids; Q = mean discharge; L = habitat unit length; W = mean wetted width/channel width; D = mean depth. A blank indicates that a variable was not determined at the site; a dash (-) indicates that the value was positive but that it was not measurable with the technique used.

Table 3. Mean values of riparian variables for 20 sites in the O'Fallon Creek system, Montana, 24 July-15 August 2002.

Site*	Variables**								
	LU	BW (m)	ER (m)	SL (m)	H-1 (m)	H-2 (m)	A-1 (°)	A-2 (°)	CS (%)
1 R	ME/ME	>10/>10	0/0	0/0	0.1/0.1	15.2/ -	90/90	160/ -	0
1 P	ME/ME	>10/>10	1.8/0	- /0	0.5/0.1	15.2/ -	90/90	160/ -	0
2 R	PA/PA	0/>10	0/0	0/0	0.1/0.1	- / -	90/90	- / -	0
2 P	PA/PA	>10/>10	0/0	0/0	0.2/0.1	- / -	90/90	- / -	0
3 P	PA/PA	0/0	- /0	0/0	- /0.1	- / -	- /90	- / -	0
3 R	PA/PA	0/0	- /0	0/0	- /0.1	- / -	- /90	- / -	0
4 R	PA/PA	0/0	- / -	0/0	0.5/ -	- / -	63/60	- / -	0
4 P	PA/PA	0/0	- />10	0/0	0.5/0.2	- /1.8	82/62	- / -	0
5 R	PA/PA	8.6/3.0	- / -	0/0	0/0	- / -	0/0	- / -	0
5 P	PA/PA	>10/3.5	- / -	0/0	0.1/ -	- / -	0/0	- / -	0
6 P	PA/PA	0/0	- /0.8	0/1.0	0/0	0.7/1.6	0/0	90/144	0
6 R	PA/PA	0/0	- /1.0	0/0	0/0	0.7/1.2	0/0	131/125	0
7 R	PA/PA	0/0	- /0	0/0	- / -	- /1.8	- / -	- /166	0
7 P	PA/PA	0/0	- / -	0/0	0.1/0.3	- / -	- / -	- / -	0
8 R	PA/PA	0/0	- / -	0/0	0.1/ -	- / -	20/ -	- / -	0
8 P	PA/PA	0/0	- / -	0/0	0.1/0.3	- / -	30/90	- / -	0
9 P	PA/PA	0/0	1.2/0	0.2/0	1.3/0.4	1.2/ -	90/90	90/ -	0
9 R	PA/PA	0/0	0/ -	0/0	0.2/ -	- / -	90/90	90/ -	0
10 R	PA/PA	0/0	- / -	0/0	0.1/0.2	- / -	77/60	- / -	0
10 P	PA/PA	0/0	- / -	0/0.2	0.3/0.7	- / -	68/96	- / -	0
11 P	PA/PA	0/0	4.0/0	2.7/0	0.7/0.2	4.6/ -	- / -	140/ -	0
11 R	PA/PA	0/0	1.7/ -	0/0	0.6/ -	2.0/ -	- / -	- / -	0
12 P	PA/PA	>10/0	- /0.6	0/0.2	0.3/0.6	- / -	54/88	- / -	0
12 R	PA/PA	>10/0	- / -	0/0	- /0.1	- / -	30/30	- / -	0
13 R	ME/ME	>10/0	0/ -	0/0	- /0.1	- / -	- /49	- / -	0
13 P	ME/ME	>10/>10	0/ -	0/0.5	0.3/0.6	- /0.4	84/45	- / -	0
14 R	PA/PA	>10/>10	0/0	0/0	0.4/0.2	2.7/2.1	90/90	160/160	0
14 P	PA/PA	>10/>10	0/0	0/0	0.2/0.4	- / 2.6	90/90	- / -	0
15 R	PA/PA	0/>10	- /0	0/0	- / -	- /1.8	- / -	- /175	0
15 P	PA/PA	0/>10	0/ -	0/0	- / -	- / -	- / -	- / -	0
16 P	PA/PA	>10/0	0/0	0/0	0.4/0.2	2.1/ -	90/90	150/ -	0
16 R	PA/PA	>10/0	1.2/ -	0/0	- / -	1.5/2.4	- / -	150/105	0
17 R	PA/PA	>10/>10	0/0	0/0	0.1/0.1	2.5/ -	- /-	140/ -	0
17 P	PA/PA	>10/>10	0/0	0/0	0.6/0.6	4.5/4.5	90/90	150/146	0
18 P	PA/PA	0/>10	3.1/0	0/0	0.3/0.4	3.7/1.0	90/90	145/87	0
19 P	PA/PA	0/>10	0/0.7	0/ -	0.3/1.7	- / -	90/90	- / -	0
20 P	PA/PA	>10/>10	0/1.4	0/0	0.1/0.1	4.7/4.8	90/90	140/142	0

* In order of downstream to upstream occurrence (R = riffle; P = pool).

**Mean values per habitat unit, where LU = land use (ME = meadow/undisturbed; PA = pasture/grazed); BW = buffer width; ER = erosion; SL = slumping; H-1 = bank height at water's edge; H-2 = entrenchment bank height; A-1 = bank angle at water's edge; A-2 = entrenchment bank angle; CS = canopy shading. A zero (0) indicates that the feature was absent. A dash (-) indicates that the value was positive but that it was negligible on the scale used; for entrenchment banks, a dash indicates that the bank was greater than 10 m from water's edge. A slash (/) separates left bank/right bank values.

Table 4. Cover variables for 20 sites in the O'Fallon Creek system, Montana, 24 July-15 August 2002.

Site*	Variables**						
	VH (cm)	VO (cm)	BU (cm)	WD (%)	OD (%)	EV (%)	SV (%)
1 R	34.7/10.0	0/0	0/0	1.6	0	0	-
1 P	48.1/ -	- /0	23.7/0	0	0	0	-
2 R	39.3/61.5	- /0	0/2.6	0	0	0	-
2 P	88.1/79.2	0/0	9.8/0	0	0	0	-
3 P	7.2/45.8	0/0	0/4.6	0	0	0	6.0
3 R	8.3/26.3	0/0	0/5.0	0	0	0	1.6
4 R	0/20.3	0/0	0/0	0	0	0	3.3
4 P	18.8/26.2	0/0	0/0	0	0	0	22.2
5 R	0.8/0.7	0/0	0/0	0	0	2.4	35.5
5 P	0.9/0.6	0/0	0/0	0	0	0.3	-
6 P	0/0	0/0	0/0	0	0	-	-
6 R	0/0	0/0	0/0	0	0	-	-
7 R	22.2/27.4	0/0	0/0	0	0	0	0
7 P	41.0/30.3	0/0	0/0	0	0	0	-
8 R	28.8/29.4	0/0	0/0	0	0	-	0
8 P	38.4/28.5	0/0	0/6.1	0	0	0	25.5
9 P	24.7/49.0	0/0	1.6/10.2	1.1	0	1.1	-
9 R	35.0/42.6	0/0	0/0	0	0	-	-
10 R	20.8/28.0	0/0	0/0	0	0	-	0
10 P	55.8/44.6	1.9/16.1	0/3.8	0	0	0	25.6
11 P	6.7/0	7.8/0	0/0	2.2	0	0	50.0
11 R	0/0	0/0	0/0	0	0	0	0
12 P	30.5/22.2	0/0	7.5/0	0	0	0	5
12 R	0/0	0/0	0/0	0	0	0	0
13 R	53.8/14.1	0/0	0/0	0	0	2.8	12.8
13 P	77.5/80.7	9.5/0	0/19.3	0	0	2.5	35.0
14 R	78.2/69.6	23.4/0	3.6/0	0	0	10.0	7.0
14 P	45.6/68.5	11.3/ -	9.9/6.8	0	0	0	16.2
15 R	8.7/12.6	0/6.6	0/1.8	0	0	0	0
15 P	18.5/0	0/0	0/0	0	0	0	46.2
16 P	33.2/50.2	0/13.6	0/6.2	0	0	0	8.3
16 R	42.7/31.8	0/4.3	0/0	0	0	12.5	12.0
17 R	64.6/65.2	57.1/ -	3.6/5.9	0	0	15.0	-
17 P	69.6/62.8	51.1/10.1	10.9/10.1	0	0	0	11.3
18 P	62.7/59.4	9.0/18.7	0/0	0	0	25.6	100.0
19 P	65.2/37.4	45.5/49.5	0/0	0	0	0	-
20 P	52.3/59.8	46.3/55.1	0/0	0	0	0	95.0

*Listed in order of downstream to upstream occurrence (R = riffle; P = pool).

**Mean values per habitat unit, where VH = vegetative height; VO = vegetative overhang; BU = bank undercut; WD = woody debris; OD = other debris; EV = emergent vegetation; SV = submerged vegetation. A slash (/) separates left bank/right bank values. A zero (0) indicates that the feature was absent. A dash (-) indicates that the value was positive but that it was negligible on the scale used.

Table 5. Streambed composition variables for 20 sites in the O'Fallon Creek system, Montana, 24 July-15 August 2002.

Site*	Substrate Composition**							Sedimentation**	
	BO (%)	RC (%)	GR (%)	SA (%)	SI (%)	CL (%)	MU (%)	SD (cm)	EM (%)
1 R	50	50						0	0
1 P	3.9		84.4		10.6			3.6	44.4
2 R	37.2	50.6	12.2					0	0
2 P		36.6	20.0				42.2	10.2	20.0
3 P	1.0	49.0	40.0		10.0			0	10.0
3 R		63.3	26.7		10.0			0	0
4 R			83.3		16.7			1.2	26.7
4 P			53.3		46.7			6.9	70.0
5 R		50.0	40.0		10.0			0	0
5 P	0.3	23.3	58.3		18.3			1.0	15.0
6 P	0.4	43.1	42.2		11.1		3.3	1.1	10.0
6 R		46.0	44.0		10.0			0	10.0
7 R		28.8	61.1		10.0			0	0
7 P		30.0	61.7		8.3			0.7	30.0
8 R		50.0	48.0		2.0			0	0
8 P	1.1	41.1	47.2		10.6			0	13.3
9 P		1.5	94.0		4.5			1.0	20.0
9 R	3.6	73.3	21.6		1.5			0	0
10 R		47.5	42.5		10.0			0	0
10 P		14.4	55.6		30.0			1.9	37.5
11 P			23.3		76.6			1.7	100.0
11 R		12.5	68.8		18.8			0	0
12 P		17.5	52.5		15.0	15.0		1.2	25.0
12 R		50.0	50.0					0	0
13 R			90.0		10.0			0	10.0
13 P		0.8	67.5		31.7			0.2	35.0
14 R		3.0	90.0		7.0			0	12.0
14 P			68.8		31.2			3.3	50.0
15 R			88.6		11.4			0	14.3
15 P			73.8		26.2			0	26.2
16 P	0.6	16.2	50.6		32.5			0.7	30.0
16 R		20.0	60.0		20.0			0	25.0
17 R	1.5	9.2	65.2		24.1			0	0
17 P			45.2		54.8			14.3	25.0
18 P							100.0	26.6	100.0
19 P			50.0				50.0	30.0	100.0
20 P			50.0				50.0	27.4	100.0

*Listed in order of downstream to upstream occurrence (R = riffle; P = pool).
**BO = boulders; RC = rubble/cobble; GR = gravel; SA = sand; SI = silt; MU = muck; SD = sediment depth; EM = embeddedness. A blank indicates that a component was not visually apparent.

Channel Morphology. O'Fallon Creek exhibited well defined riffle-pool development, although riffles were often dry under the prevailing low flow conditions. Pools ranged from 16 m to greater than 400 m in length, averaging 6.9 m in wetted width and 35.7 cm in depth. Riffles ranged from 10 m to 85 m in length, averaging 3.1 m in wetted width and 4.9 cm in depth. Because of low flow conditions, channel width was usually more than wetted width (Table 2).

Riparian Conditions. Adjacent land use at most sites on O'Fallon Creek was pasture. Riparian erosion and slumping were minimal and were largely restricted to high angle faces of entrenchment banks (Figure 5). At many sites we evaluated buffer width (width of undisturbed riparian vegetation) as 0 because grazing had modified natural riparian vegetation cover. However, in most locations this indicated a reduction in vegetation height, not the presence of bare soil or erosion. Banks at water's edge were low, usually less than 0.5 m, and approximately vertical, while most of the channel was entrenched between secondary banks with an average height of 3.2 m and an average angle of 136°. We did not measure entrenchment banks greater than 10 m from water's edge. Although eastern cottonwoods were frequently adjacent to the channel, they were never close enough to provide canopy shading (Table 3).

Cover. Vegetative height at water's edge averaged 60.2 cm, ranging from 0.0 cm to 88.1 cm (Figure 10). Vegetative overhang was absent or negligible at many sites; where present, it averaged 24.2 cm (Table 4). Instream cover, including bank undercut, woody debris, other debris, emergent vegetation, and submerged vegetation, was generally scarce. Most pools had some submerged aquatic vegetation, mostly *Ceratophyllum* sp. and *Chara* sp., but it was difficult to visually assess its extent due to high turbidity. Significant amounts of submerged vegetation were observed at Site 18, where it covered almost 100% of the channel bottom (Table 4). Attached filamentous algae covered the streambed material in most riffles. The most important cover in O'Fallon Creek may consist of "virtual" cover provided by tall riparian vegetation.

Streambed Composition. The predominant substrate materials in O'Fallon Creek were rubble, cobbles, and gravel associated with some silt embeddedness at all sites (Table 5). Riffles generally exhibited higher proportions of rubble and cobble than did pools. Boulders were common only at Sites 1 and 2, where they were associated with the Yellowstone River floodplain terraces (Figure 11). Few pools were deeply sedimented; where significant sediment depth was evident, it occurred in isolated littoral pockets and consisted mostly of submerged riparian soil. The channel bottom at Sites 18, 19 (Sandstone Creek), and 20 (Pennel Creek) consisted of deep muck, probably the product of decaying aquatic vegetation in a lentic environment. Sites 19 and 20 were located in long beaver impoundments.

Fish Communities. Table 6 is a checklist of fish species that have been collected in the O'Fallon Creek system since 1975. To date, 33 species have been collected in the system, to which we added only one new record, brook stickleback (*Culaea inconstans*), from Site 18 in 2001.

We failed to collect certain riverine species previously collected near the mouth of O'Fallon Creek, including mountain sucker (*Catostomus platyrhynchus*), blue sucker (*Cycleptus elongatus*), bigmouth buffalo (*Ictiobus cyprinellus*), yellow bullhead (*Ameiurus natalis*), sauger (*Stizostedion canadense*), and walleye (*Stizostedion vitreum*). These are primarily Yellowstone River species which may stray or seasonally migrate into the mouth of O'Fallon Creek, and we did not expend a major part of our sampling effort in that area.

Table 6. Species and numbers of fishes collected in the O'Fallon Creek system, Montana.*

Species	Pre-1981	2000	2001	2002	Total
goldeye (*Hiodon alosoides*)	+		2	5	7
lake chub (*Couesius plumbeus*)	+				
common carp (*Cyprinus carpio*	+		47	219	266
western silvery/plains minnow (*Hybognathus argyritus/placitus*)	+	34	194	32	260
brassy minnow (*Hybognathus hankinsoni*)	+	12	66	204	282
golden shiner (*Notemigonus crysoleucas*)	+				
emerald shiner (*Notropis atherinoides*)	+		17	16	33
sand shiner (*Notropis stramineus*)	+	129	253	1134	1516
fathead minnow (*Pimephales promelas*)	+	64	258	2565	2887
flathead chub (*Platygobio gracilis*)	+	3	162	50	215
longnose dace (*Rhinichthys cataractae*)	+		7	82	89
creek chub (*Semotilus atromaculatus*)	+	22	97	392	511
river carpsucker (*Carpiodes carpio*)	+		22	48	70
longnose sucker (*Catostomus catostomus*)	+		55		55
white sucker (*Catostomus commersoni*)	+	163	214	1175	1552
mountain sucker (*Catostomus platyrhynchus*)	+				
blue sucker (*Cycleptus elongatus*)	+				
smallmouth buffalo (*Ictiobus bubalus*)	+			17	17
bigmouth buffalo (*Ictiobus cyprinellus*)	+				
shorthead redhorse (*Moxostoma macrolepidotum*)	+	1	18	55	74
black bullhead (*Ameiurus melas*)	+		21	166	187
yellow bullhead (*Ameiurus natalis*)	+				
channel catfish (*Ictalurus punctatus*)	+	1	64	181	246
stonecat (*Noturus flavus*)	+	1	4	44	49
northern pike (*Esox lucius*)	+			1	1
plains killifish (*Fundulus zebrinus*)	+	7	45	328	380
brook stickleback (*Culaea inconstans*)			11		11
green sunfish (*Lepomis cyanellus*)	+	2	15	775	792
pumpkinseed (*Lepomis gibbosus*)	+				
bluegill (*Lepomis macrochirus*)	+				
yellow perch (*Perca flavescens*)	+			33	33
sauger (*Stizostedion canadense*)	+				
walleye (*Stizostedion vitreum*)	+				
TOTAL FISH		439	1572	7522	9533
TOTAL SPECIES	32	12	20	21	33

*Pre-1981 based on Elser et al. (1980) and Morris et al. (1981); 2000 courtesy of Robert G. Bramblett, Montana State University, Department of Ecology (personal communication, 2000); 2001 based on Barnes et al. (2002); 2002 based on present study. Common and scientific names are according to Robins et al. (1991). A plus (+) means present but numerical data not available.

We collected 181 channel catfish (*Ictalurus punctatus*) as far upstream as Site 16 (Table 8); most of these were young-of-year, indicating the use of O'Fallon Creek by channel catfish as a spawning and nursery area. We collected one northern pike (*Esox lucius*) approximately 50 cm long from an isolated pool at Site 12. Yellow perch (*Perca flavescens*), mostly young-of-year or yearlings, were collected in small numbers at several sites but were common at Site 19 in Sandstone Creek. These were probably escapes from an impoundment on South Sandstone Creek, where yellow perch have been stocked in South Sandstone Creek Wildlife Management Area.

We did not collect pumpkinseed (*Lepomis gibbosus*) or bluegill (*Lepomis macrochirus*). These were collected in small numbers at several upstream sites before 1980 and may represent escapes from populations stocked in ponds and reservoirs in the watershed.

As in 2001, fish communities in riffle habitats were curiously depauperate, with fathead minnow (*Pimephales promelas*) and sand shiner (*Notropis stramineus*) representing the most commonly encountered species (Table 7). Longnose dace (*Rhinichthys cataractae*) and stonecats (*Noturus flavus*), which dominated riffle fish communities in Burns Creek (Barnes 1997, Barnes 1999, Barnes and Westlind 2000, Barnes and Silbernagel 2001), were scarce in O'Fallon Creek. We previously speculated that the scarcity of riffle fishes in O'Fallon Creek during sampling in 2001 was due to a flushing effect following a major storm flow event in late July 2001 (Barnes et al. 2002). It now seems more likely that seasonally dry riffles discourage the establishment of well developed populations of riffle dependent species such as longnose dace and stonecat in O'Fallon Creek.

The most abundant and widely distributed pool species were sand shiner, fathead minnow, creek chub (*Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), and green sunfish (*Lepomis cyanellus*) (Table 8). Common carp (*Cyprinus carpio*), brassy minnow (*Hybognathus hankinsoni*), longnose dace, shorthead redhorse (*Moxostoma macrolepidotum*), black bullhead (*Ictalurus ameiurus*), channel catfish, stonecat, and plains killifish (*Fundulus zebrinus*) were collected in smaller numbers in the majority of pool habitats. Goldeye (*Hiodon alosoides*), western silvery/plains minnow (*Hybognathus argyritus/placitus*), emerald shiner (*Notropis atherinoides*), flathead chub (*Platygobio gracilis*), river carpsucker (*Carpiodes carpio*), and smallmouth buffalo (*Ictiobus bubalus*), species primarily associated with larger stream and riverine habitats, were mostly collected in the lower half of the stream system.

We were unable to estimate densities of fish communities in riffles due to low flow and poor capture rates (Table 9). Density estimates in pools varied greatly, from 22 fish/100 m^2 at Site 2 to 918 fish/100 m^2 at Site 11. There was no clear relationship between fish population density and the macrohabitat variables we measured. Site 11, with the highest population density, exhibited the "poorest" habitat quality (a shallow, isolated, turbid, 117-m^2 pool in a washed out beaver pond with low DO, no vegetation, and no cover) (Figure 9).

In Burns Creek, contingent phenomena such as storm flow flushing and distribution of beaver dams in time and space were thought to influence fish community density and diversity as much as relatively "fixed" macrohabitat factors (Barnes and Silbernagel 2001). However, Burns Creek exhibited perennial flow, so fish communities could at least partially stabilize.

Table 7. **Numbers of fishes collected in riffle habitats, O'Fallon Creek, Montana, 24 July-15 August 2002.**

	Site																			
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18***	**19***	**20***
goldeye																				
common carp			5																	
western silvery/ plains minnow		1	2																	
brassy minnow																				
emerald shiner																				
sand shiner			51	15									7		2					
fathead minnow			42		1	8														
flathead chub				4																
longnose dace	3			25									1	1						
creek chub	3		5	8	1								1	1						
river carpsucker	1		2																	
white sucker			6	3									1							
smallmouth buffalo																				
shorthead redhorse			1																	
black bullhead																				
channel catfish			6																	
stonecat	3	3	4	3																
northern pike																				
plains killifish			1	2	2	13								1	6					
green sunfish													38							
yellow perch																				
TOTAL	10	4	125	60	4	25	0	0	0	0	0	0	48	3	8	0	0	N/A	N/A	N/A

*No riffle habitats.

Table 8. **Numbers of fishes collected in pool habitats, O'Fallon Creek, Montana, 24 July-15 August 2002.**

	Site																			
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
goldeye									2		3								2	
common carp	8			10	7	13	12	8	4	60	9		3	51	6	5	24			1
western silvery/ plains minnow	27	9		2																
brassy minnow				3	25	40	2	1	11				26	16	19	49	5		7	
emerald shiner	11	1		4		116														
sand shiner	6	11	70	208	181	69	2	4	64	19	120	49	124	64	45	87	2			
fathead minnow	19	15		500		179	283	111	73	206	229	57	70	32	195	174	4		100	85
flathead chub	29		1	13	7			14	2			1								
longnose dace			1		44	3				8	2	1	18			2				
creek chub	3	8	2	45		52	1		7	17	39	2	93	9	3	22	11			1
river carpsucker	1	10						1	32				1							
white sucker	5	7		74	60	226	44	27	15	19	189	2	149	87	30	202	15		3	11
smallmouth buffalo	17																			
shorthead redhorse	1				8				2	1	7		1	19	10	5				
black bullhead							1		16		90		40	7		12				
channel catfish	3		1		2	1	2	4	3		69	3	63	19	1	29			5	
stonecat		1	1		1		1	4	1	2	20				1					
northern pike												1								
plains killifish	20	1		16		37	1	1		13	2	1	48	1	111	1				
green sunfish				4	17	6	18	13	7	199	196	4	19	5	97	138	2		33	12
yellow perch									1		1		8			1			22	
TOTAL	150	63	76	883	468	626	367	188	240	544	976	121	663	310	518	727	63	0	172	110

Table 9. Estimated densities of fish populations in riffle and pool habitats in the O'Fallon Creek system, Montana, 24 July-15 August 2002.

Habitat	Sites & Estimated Densities (Individuals/100 m^2)*																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Riffles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Pools	55	22	92	772	215	327	79	46	27	162	918	144	363	287	361	846	-	-	-	-

*A dash (-) indicates that an estimate was not attempted due to low capture rate or failure to achieve a catch reduction.

In O'Fallon Creek, a similar contingent phenomenon may be the timing and extent of riffle dewatering in the summer. Fish moving upstream or downstream may be trapped, often at very high densities, in shrinking pools with low quality habitat as riffles dry up and interrupt the hydrologic continuity of the stream. Similarly, drying riffles may exclude fish from preferred habitats. The overall "flashiness" of the stream system probably prevents fish communities from stabilizing and efficiently partitioning available habitats.

O'Fallon Creek is clearly a highly variable system in which extreme high and low flow, high TSS, and high TDS present survival challenges to the resident fish communities. These factors may override other macrohabitat variables, such as substrate composition and instream cover, in controlling density and distribution of these communities. An understanding of the relationships among fish communities, macrohabitat variables, and contingent phenomena in O'Fallon Creek would require several years of study under a full range of natural environmental variation.

General Work Plan for 2002. We would like to continue our study of fish communities and macrohabitat variables in O'Fallon Creek during the summer of 2003, using the same basic approach and trying to sample at least two more sites in Sandstone Creek and Pennel Creek.

Acknowledgments. We would like to thank the Montana Department of Fish, Wildlife, and Parks, particularly Brad Schmitz and Vic Riggs in Miles City, for logistical support of this research. We would also like to thank Pat Newby and the Montana Department of Environmental Quality for financial and logistical support. Landowners in the O'Fallon Creek area graciously provided access privileges and information without which this study would not have been possible.

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